DESIGN OF AN APPROACH FOR A PROPOSED BRIDGE ACROSS THE CHICAGO RIVER AT LA SALLE ST.

CHICAGO, ILLS.

BY

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1908

DESIGN OF AN

APPROACH FOR A PROPOSED BRIDGE

ACROSS THE CHICAGO RIVER AT

LA SALLE STREET, CHICAGO, ILLS.

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A THESIS PRESENTED

BY

William J. Converse

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[illegible] Cerny

TO THE

PRESIDENT AND FACULTY

OF

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FOR THE DEGREE OF

BACHELOR OF SCIENCE IN CIVIL ENGINEERING

HAVING COMPLETED THE PRESCRIBED COURSE

IN

CIVIL ENGINEERING

CHICAGO, ILLS.

[illegible].

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THESIS DESIGN

OF

AN APPROACH FOR A PROPOSED BRIDGE ACROSS THE CHICAGO RIVER AT LA SALLE STREET, CHICAGO, ILLS.

INTRODUCTORY REMARKS

There remains no doubt but that in the near future Chicago will require another bridge across the Chicago River joining the North side and the Loop district. This is made necessary because of the increasing amount of traffic, both trucking and street car, which is now only indifferently accomodated by the five existing bridges at Wells St., Clark St., Dearborn St., State St. and Rush Street. The latter bridge does not carry any car tracks, hence the other four bridges are badly congested during the rush hours.

Another reason for a new bridge lies in the fact that a "boulevard link" or boulevard and bridge connecting the North side boulevards with those of the West and South sides has been proposed and even planned for this street. At present nothing of the kind exists except the poor makeshift consisting of Michigan Avenue, the Rush Street Bridge and Ohio Street. Notwithstanding the fact that there are objections to this plan such as a detour away from the lake front, where the boulevard perhaps should be, the extreme length to be paved and other

minor considerations, there still remains several good reasons why it would be a good plan. It would connect readily with Jackson Boulevard on the south and, by means of Ohio Street, with Lincoln Park Boulevard on the north. There are few car lines on La Salle Street or Avenue to be removed since there is only the small loop from Randolph St. to Monroe St. La Salle St. is not a business street in the sense that State street is and for that reason the traffic of trucks which would be diverted to other streets would be but a slight disadvantage.

At any rate, a bridge will soon be necessary and on account of the restrictions and rules of the Sanitary District we may assume that it will be a bascule, roller-lift bridge of some kind. Center pier drawbridges of sufficient span are unwieldy and involve too great a loss of time in opening and closing beside the added disadvantage of obstructing river traffic on account of the center pier and pile guards necessary.

The Sanitary District specifications require a waterway of 200' by $21\frac{1}{2}$'. This can be provided, and has been at Clark and Dearborn Sts., where similar bridges have been erected by means of by-passes between the bridge foundations and the dock line, and this is done so that the span of the leaves will not be too long. The span of the Dearborn St. Bridge is 154.[illegible]' and the clear waterway between protection cribs is 142'. By measurement the river is 280.5' wide at La Salle St.

From the profile, Plate I, it can be seen that no

structural approach is necessary at the south end, although the grade will be quite steep. However, a similar or even greater grade is used at some of the other bridges and will be used here. On the North side, owing to the Chicago and Northwestern Ry. tracks, it will be necessary to start the approach at Kinzie street and bring it up by the easiest possible grades over these tracks and then down again to the bridge, whose elevation is practically fixed on account of the south approach and river traffic. To obtain enough head room over the tracks and yet not have prohibitive grades on the approach we found it necessary to lower the tracks at this point. From elevations it was found that the tracks were about 2½' higher here than they were at either Clark St., or Wells St., so that they could be lowered without any inconvenience. Thus allowing 2' 4" for depth of floor beams over the tracks, or rather between top of pavement and low iron, we have a head room of 16' 10" clear which is deemed sufficient and is, in fact, the maximum at the Clark Street approach.

It will be necessary to afford a team-way at one side of the approach to permit access to the warehouses along North Water St. Taking this at 20', which is ample room for two trucks to pass, we have 60' left for roadway and sidewalks, since the street is 80' wide. This is divided as follows: roadway 40' and sidewalks 10' each. Since the teamway is at one side the approach must be on a skew and this is arranged so as to be gradual to the bridge, excepting the span across

the tracks which will be parallel with the centerline of the street.

In order to provide entrance to the blind alley on the west side of La Salle Avenue between Kinzie and North Water Sts. it will be necessary to build the retaining wall north of this alley. From these considerations the approach from here to the girder will be divided into three spans of 34' each and to simplify design, details and shopwork the spans on the other sides of the girder will be also 34' in length.

In order to afford a driveway on each side of the outer tracks or to permit of another track being laid we take the span of the track girders as 74' or six panels of 12' 4" each. Owing to the arrangement of the tracks it is possible to divide this into two spans of 37' each but to provide as much unabstructed passage as possible and also to provide for future rearrangement of the tracks it was deemed best to make it one span of 74'.

From this point on to the river we have 34' spans as stated before except in the last panel which is 7' [illegible]" in length. This panel is securely braced both transversely, longitudinally and diagonally to withstand the shock from the bridge structure itself as well as the approach. Since the entire structure is about 354' in length it is necessary to provide several expansion joints. To obtain as much rigidity as possible the track girder has no expansion joint at either end; besides it

would expand only about .43" for a 75° range of temperature. However, expansion joints are provided at other points as shown on Plate VI and in detail on Plate III.

PLATES

Plate I shows a map and profile of La Salle St. and Ave. (it being called La Salle Ave. north of the river) from Lake St. to Kinzie St. The field work was done in the latter part of 1907 and included a traverse, triangular measurement of the distance across the river, and a line of levels. The levels were run from a B. M. at the N. E. Corner of La Salle and Randolph Sts.

Plate II shows the middle girder across the tracks and its floor beams and connections as well as the post and bracing.

Plate III shows the outside girder of the same span besides the floor beam and sidewalk connections, and posts.

Plate IV is a section of the approach at A - A Plate VI. It shows the details of the expansion joints and column footings which are used throughout the structure.

Plate V. shows the construction of the end panel with its bracing.

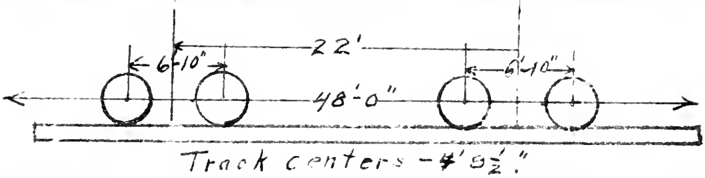
Plate VI. is an elevation and plan of the completed structure with the location of the columns, expansion joints, elevations, etc.

Plate VII. is a plan and elevation of the retaining wall

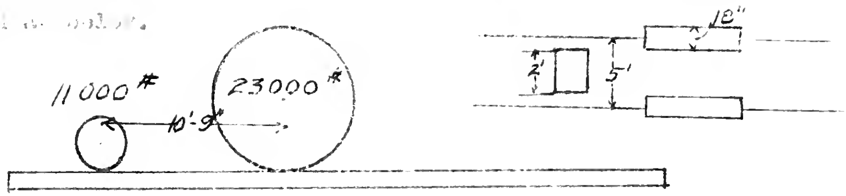
[illegible] railing [illegible] construction.

[illegible]

[illegible]



[illegible] roller, [illegible]



Uniform live load [illegible] of bridge and sidewalk. [illegible]

[illegible]

[illegible]

[illegible] sidewalks, supported on [illegible] in thickness to give [illegible]

The roadway will be paved with first class Shuman Paving resting on transverse 1" oak strips 4" wide and spaced 3" apart. These are laid on 4"x [illegible]" yellow pine placed diagonally at an angle of 45° and 6" apart. These rest directly on the stringers to which they are attached by hook spikes.

The sidewalk flooring will be guarded by a 3½"x 3½" x 7/8" angle on the edge as will also be the 6"x [illegible]" oak guard timbers on the girder span.

Retaining Walls, and Column Footings.

These will be constructed of concrete, one part of cement to 2½ parts of sand and five parts of crushed stone, well mixed and placed in substantial forms. The cement may be any first class brand which will comply with the specification of the A. S. C. E. The sand must be clean, sharp and of graded sizes. The stone must be first quality limestone of graded sizes. The column bases must be filled with cement mortar up to the top of the side plates. The sidewalks on the approach up to the retaining wall will be of 1--2½--5 concrete on a 6" cinder base. The fill back of the retaining wall will be of compacted earth and the paving will be of granite blocks.

Street Car Tracks.

The street car tracks will be standard 7" girder rails and will rest directly on the stringers to which they will be bolted. On the structure the center lines will be spaced 12'- 0"

apart and will gradually converge [illegible] to 9' 6" at Kinzie street.

[illegible] II

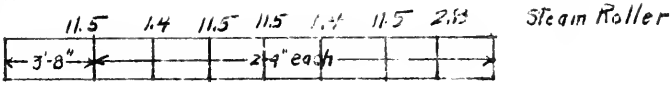
As noted above, the structure will be divided into one girder span of 74', eight panels of [illegible]4' and an end panel of 7' [illegible]".

Design of Main Girder Stringers.

There will be three girders spaced 2[illegible]' apart with floor beam spacing of 12' 4". The maximum bending moment for the 12' 4" stringer will occur when the steam roller is in the middle of the stringer and will equal 1[illegible] x [illegible]' [illegible]" = 71 kip-feet on two stringers, or 35[illegible] kip-feet on one stringer. Assuming the weight of flooring as 4.[illegible] per board foot, the floor load when the stringers are placed 2' [illegible]" apart would be 4.[illegible] x [illegible]/[illegible] x 2 [illegible]/[illegible] x 1[illegible] [illegible]/[illegible] = .[illegible] kips, since there are about 4 3/4 bd. ft. per sq. ft. of floor area. Then the bending moment equals $\frac{.[illegible] \times 12\ 1/[illegible]}{[illegible]}$ = .[illegible]41 kip-feet.

The street car gives a moment of [illegible] kip-feet; therefore, the steam roller gives the largest moment and will be used. Then the total moment equals [illegible].1 kip-feet. This gives a section modulus of $\frac{[illegible]7.1 \times 12}{16}$ = [illegible]. Therefore, use a 12" [illegible]" I beam.

Floor Beam.



Stringers will be placed 5' 4" apart excepting the first car track stringer which will be 5' 5" from the middle girder. Assume dead load of floor beam as 150# per foot of length. The maxium live load reaction comes with two steam rollers at the panel points and gives a moment of 152.00 kip-feet. The moment due to stringers equals 19.35 kip-feet. Moment due to floor beam equals 7.50 kip-feet. Moment due to live load of 100# per sq. ft. equals 18.04 kip-feet. This gives a total moment of 197.22 kip-feet, or 2366.64 kip-inches. We will try an 18" x 3/8" web plate and 4"x 4"x 1/4" and one 9"x ½" cover plate. This gives an area of 10.88 plus 4.5 or 15.38 sq. ins. Subtracting rivets we have a net area of 11.38 sq. ins; required area equals $\frac{2366.64}{13 \times 16.34}$ = 11.12 sq. ins. Therefore, we will use 4"x 4"x 1/4" angles and one 9"x ½" cover plate.

Testing the web plate for shear we have a total shear of 32.[illegible] kips. This divided by 12.5 equals 2.[illegible] sq. ins., the required area. We have 18 x 3/8" or 6.75 sq. ins., or a net area of 5.75 sq. ins. This gives us 4.12 sq. ins. for rivets, or room for 11 rivets. Therefore, we can use an 18"x 3/8" web plate.

End Floor Beam.

The reaction due to street car will be 29.7 kips on one stringer and 11.5 and 7.2 kips due to steam roller, and 1.10 kips due to flooring and 1.53 kips due to stringers which will give a total reaction of 47.31 kips at the inside girder, and 52.?2 kips at the outside girder. This gives us a total moment of ?28?.? kip-ins. Trying ?"x ?"x ?/?" angles and 13"x ?" web plate we have a total flange area of 12.02 sq. ins. The required area equals $\frac{?27.3}{?? \times 1?.?} =$ 11.? sq. ins. Therefore, we will use this section. Testing the web plate in which we have [illegible] sq. in., or a net area of ?.3 sq. in., the shearing [illegible] to 12,500 - 30 x 1? x ?" = ?360? per sq. in. The maximum shear of 52 20 when divided by 9360 equals ?.? sq. in., so we will use a 1?"x ?" web plate. Dividing the shear by the effective depth, or $\frac{?2820}{14.?4}$ = 3??.2# per sq. in. is the stress per lineal inch which must be transferred from flange to web. The bearing value of a ?/?" rivet in a ?" plate is ?1??# per sq. in. Therefore, $\frac{?4??}{3???}$ = 1.?" rivet spacing. Similarly we find spacing of 2.21" and 3.?" between the next stringers.

Middle Girder.

The live load moment due to street car equal 1??2.4 kip-feet. That due to steam roller equals ?.? kip-feet. Moment due to live load of 100# per sq. ft. equals 547.3

kip-feet. That due to dead load equals 983.79 kip-feet. And the portion of this total going to the middle girder from one-half the bridge, will be 1468.06 kip-feet, --or a total of 35250 kip-ins. [illegible] the whole bridge. Trying [illegible]"x [illegible]"x [illegible]/4" angles, one 17"x [illegible]/8" plate and two 17"x 3/[illegible]" plates, we get a required area of 38.50 sq. ins., and a net area of 40.[illegible]1 sq. ins., and therefore, use this section.

For rivet spacing we have a stress of $\frac{135470}{70\ 5}$ = 1919# per lineal inch of flange. Therefore, the spacing in the first panel will be $\frac{5070}{1919}$ = 2.64" or say 2.5", and 50.70 divided by $\frac{108[illegible]}{7063}$ or 3.5" in the next panel.

Outside Girder.

In the outside girders we have a bending moment of 23408 kip-ins., and use [illegible]"x [illegible]"x 7/[illegible]" angles and one 1[illegible]"x [illegible]/8" plate. For the rivet spacing we have 5070 divided by $\frac{107060}{7032}$ = 3.33" for the first panel and similarly 4.[illegible]" for the second panel.

The web plates in all girders will be 72"x [illegible]/[illegible]" plates and 5"x [illegible]"x [illegible]/8" stiffeners spaced [illegible]' [illegible] 1/2" apart will be used. The plate has an area of 27 sq. ins. and the required area is $\frac{135470}{12[illegible]}$ = 10.[illegible] sq. ins. for the middle girder; this leaves room for 1[illegible].1 divided by [illegible] or [illegible] rivets but a smaller web should not be used.

Main Girder Sidewalk.

The stringers will be 12' 4" long and spaced 2' 6" apart The total moment is 3910 kip ins., and we use 6" 12.25# I beams.

Sidewalk Floor Beams.

The floor beams are 10' cantilevers. The total bending moment is 961.44 kip ins., and we can use a 24" and 8"x3/8" web plate and $3\frac{1}{2}$"x $3\frac{1}{2}$"x $\frac{1}{2}$" angles. The total shear is 17.60 kips, and we need $\frac{17600}{2357}$ or eight rivets for connections, since the shearing value of 3/4" field rivets for floor system is 2357#

End Sidewalk Floor Beams.

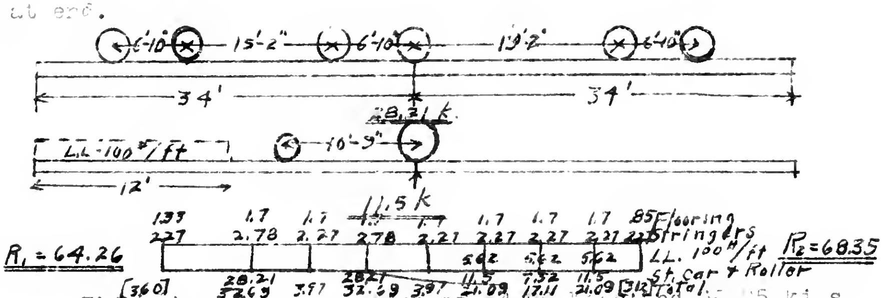
For the end sidewalk floor beam the total bending moment is 1305.7 kip-ins. and we can use $3\frac{1}{2}$"x $3\frac{1}{2}$"x /4" angles. The total shear is 370 kips, and we need 17 rivets for connections.

34' Panels--Stringers.

The stringers will be spaced 2' 4" apart and have a total bending moment of 11 .618 kip-ft. for those under the steam roller, and 151. kips for those under the car tracks, and we can use 20" # I beams for the former, and 20" 80# I beams for the latter. For connections, dividing the total shear of 21315# by 2357#, the shearing value of a 3/4" field rivet for floor system, we will need ten rivets.

34' Panels--Floor Beams

The maximum stringer reaction for the street car in two panels is 28.21 kips; for the steam roller it is 11.5 kips on the outer stringer and 7.52 kips on the inner stringer covered by it. The flooring gives a reaction of 1.7 kips; the stringers 2.27 kips and 2.78 kips, the latter being under the car tracks; the live load of 100# sq. ft. on the rest of the bridge gives a reaction of 4 kips at the outside end and 7.93 kips at the second, third and fourth stringers from that end.



This gives us a reaction of 64.26 kips and 68.35 kips, not including the end loads, at the inner and outer ends respectively. Then the bending moment would be 64.26 x 10 2/3 x 12--(32.69 x 9 1/3-3.97 x 4 2/3) x 12 = 4341.6 kip inches.

Trying 4"x 6"x 7/8" angles and one 9"x /" plate, we have a net area of 12.28 sq. ins., and a required area of $\frac{4341.6}{13 \times 27.21}$ = 12.26 sq. ins. Therefore the above section will be used. Trying a 30"x 3/8" web plate we have a net area of 9.28 sq. ins. $\frac{47.260}{.28}$ = 5092# per sq. in., the shearing stress on the web plate. The safe stress is 12500- 90 x

30 x /3 = 5300. Therefore we can use a 5/8" web plate. The bearing value of a 3/4" rivet in a 5/8" plate for floor system is 4728#. Therefore the rivet spacing will be 4728 divided by $\frac{63550}{27.21}$ or about 2" and similarly it will be 2.7" and 4" in the next sections.

Sidewalk Stringers--34' Panels.

These stringers are spaced 2' 6" apart and the total bending moment is 305.00 kip-inches. This gives us a section modulus of 40.60, hence we can use 12" 45# I beams, whose modulus is 47.6. For connections we require $\frac{6.036}{2.357}$ or 3 rivets.

Sidewalk Floor Beam --34' Panels

For 34' panels with the stringers spaced 2½' apart, we have a total bending moment on the cantilever of 2459.8 kip-ins. Assume an extension of the floor beam section already designed. The net area of flanges as designed equals 12.3". This gives us a possible effective depth of $\frac{2459.8}{13 \times 12.}$ 13 +". Therefore, an extension of section already designed is all right. For the rivet spacing we have 4728 divided by $\frac{39140}{27.21}$ or 3.3"

End Panel Stringers.

For the end panel we have a total bending moment of 22.049 kip feet and can use 9" 25# I beams. For the sidewalk we will use 12" 31.5# I beams, which, though heavier

than needed, will obviate the use of complicated connections and details.

End Panel Floor Beams.

Here we have loadings from $\frac{1}{2}$ the 34' panel and $\frac{1}{2}$ of the 7' 6" panel and get a total bending moment of 2523.750 kip-inches. Trying a 21 x 3/8" web plate, 4"x 4"x 3/4" angles and a 9"x 5/8" cover plate we have a net flange area of 10.505 sq. ins. and a required area of 10.14 sq. ins. Therefore we will use the above section. For the last floor beam we will use the same section but there will probably be a floor beam designed by the Sanitary District resting on the column beside it.

Girder Posts.

For the middle post we have a live load reaction of 140.49 kips; a total dead load reaction of 73.80 kips or an equivalent live load reaction of 17 .45 kips. Trying a 10" -- 7/16" Z bar column, we have an area of 2.3 sq. ins.; the safe stress equal 11,000 $- 40 \times \frac{1}{r} =$ 8454$\frac{?}{?}$ per sq. ins when l equals 17' or 204" and r = 3.1 . This gives us a required area of 21 sq. ins. Therefore, we can use the 10" - 7/16" Z bar column. On the outside posts we have an equivalent live load of 160.? kips and will use the same section.

Bed Plates

The total load on the largest column equals 214.[illegible]9 kips. With an allowable pressure of 250# per sq. in. on the masonry we require $\frac{214[illegible]0}{2[illegible]0}$ = 5[illegible] sq. ins. as the area of the bed plate. Using [illegible]"x 8" angles the bed plate must be 1[illegible]" plus 10[illegible]" + 1", or 27[illegible]" wide. Therefore, we will use a 28"x [illegible]2" bed plate.

Approach Posts.

On the inner approach posts we have a total equivalent live load reaction of 11[illegible].[illegible] kips. Trying 12" [illegible]# channels, with an area of 14.7 sq. ins., we have a safe stress of 11,[illegible]0 - $\frac{[illegible]1[illegible]0}{4.43}$ = [illegible]15[illegible]# per sq. in., or a required area of 12.2 sq. ins. Therefore, we use 12" [illegible]# channels for middle posts. On the outer posts we have an equivalent live load reaction of 104.[illegible] kips and can use 12" 20½# channels for the outside posts.

Bed Plates.

Under these columns with the maximum reaction of 1[illegible]4.7[illegible] kips we need $\frac{1[illegible]47[illegible]}{[illegible]}$ = [illegible] sq. in. Using [illegible]" angles the plate must be [illegible] x [illegible]"+ [illegible]2"+ 1" or [illegible]" wide. We will therefore make it [illegible]5"x [illegible]".

Anchor Rods and Plates.

We will use a column base [illegible] designed by Waddell [illegible] elevated railroads [illegible] having 7/[illegible]" angles, [illegible]" vertical plates and 7/[illegible]" bed plates. The anchor rods are 1[illegible]" in diameter [illegible] 1[illegible]" apart in [illegible] channel columns and 1[illegible]" [illegible] bar columns. [illegible] curved plate [illegible] and [illegible] nuts. [illegible] anchor plate as shown in Plate IV by spacing the bolts [illegible] 1[illegible]" [illegible].

Column Footings.

We will assume the weight of earth as 100# per cu. ft. since the columns will be placed in the street where the earth is quite consolidated. We will take the angle of repose of the earth as [illegible]°. [illegible] middle columns of the girder must be [illegible]. A footing [illegible] square we will have a bearing value on the earth of $\frac{[illegible]}{[illegible].25}$ = [illegible]11# per sq. ft. [illegible] footing must be sunk to prevent the upheaval of the earth, we have q' = 100 d where d is the required depth. Then $\frac{q'}{[illegible]}$ = $\frac{(1 - \sin [illegible])}{(1 + \sin [illegible])}$ = .[illegible] 100 [illegible] = .[illegible] 1 x [illegible] 4.0[illegible]

Retaining Wall.

The retaining [illegible] tains earth sloping [illegible].

the wall as if the surface were horizontal. [illegible] ing ϕ or the angle of repose as 2[illegible]°, the weight of earth as 130# per cu. ft., the height as [illegible] feet and the weight of concrete as 1[illegible]# per cu. ft., in Rankine's formula:

$$P + W \times h \times t \times [illegible] = \frac{w'h^2}{[illegible]} \times \frac{1 - \sin\phi}{1 + \sin\phi} \times 1/[illegible],$$

to find t the thickness of the wall at the base. Thus

$$1[illegible]60 + 1[illegible] \times [illegible] \times [illegible] = \frac{130 \times [illegible]}{[illegible]} \; [illegible].3 \; \times [illegible],$$

since P the dead load reaction [illegible] of wall, equals 1[illegible]0#

[illegible] this [illegible] it [illegible] below [illegible]. [illegible] safety we [illegible].

[illegible] in we find [illegible] the wall [illegible]0' long has a base of [illegible] or [illegible] an allowable pressure [illegible] only [illegible] per sq. ft. which is [illegible] low [illegible] wall [illegible] bear [illegible]. [illegible] most conditions this foundation is [illegible]ible [illegible] footings used.

We will [illegible] 'x 5' [illegible] wall sunk [illegible]' below the surface [illegible].

THESIS DESIGN

of a

PROPOSED BRIDGE APPROACH

LASALLE AVENUE, CHICAGO, ILLINOIS.

PLATE I.

PROFILE and PLAT.

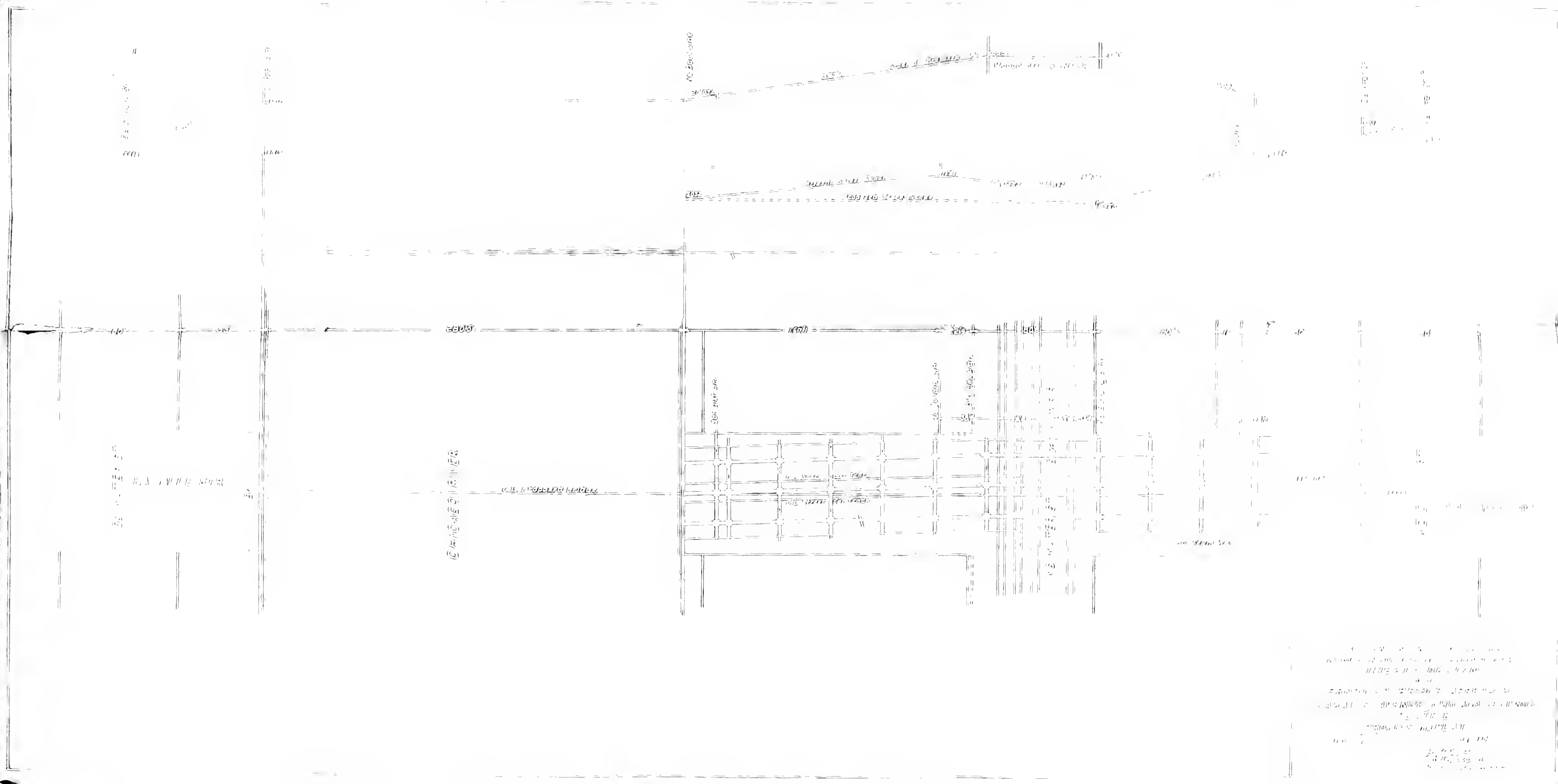
Scale- { Hor. 1" = 30'. Ver. 1" = 6'.

May, 1908.

J. Cerny

R. L. Larson.

Wm. J. Converse



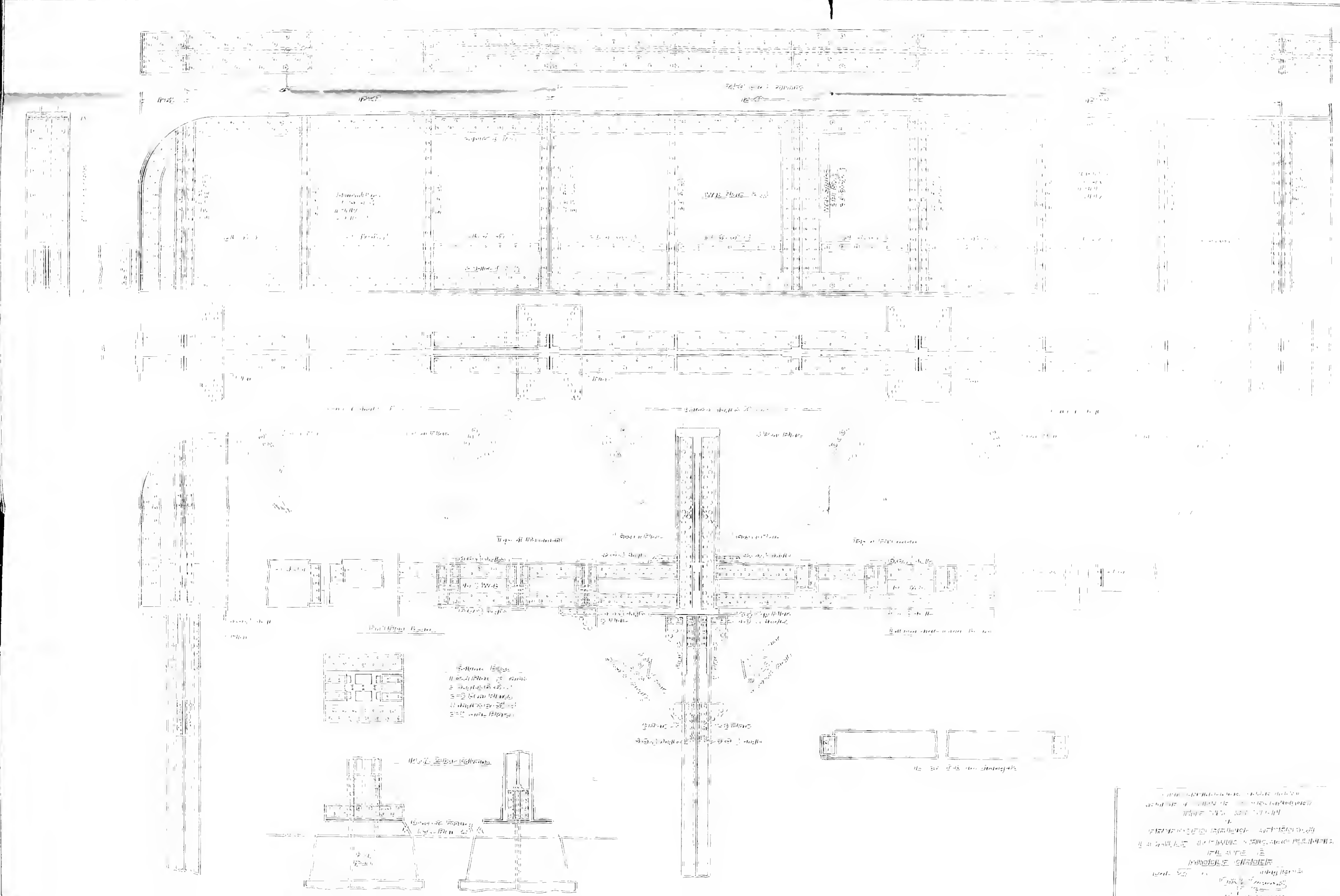
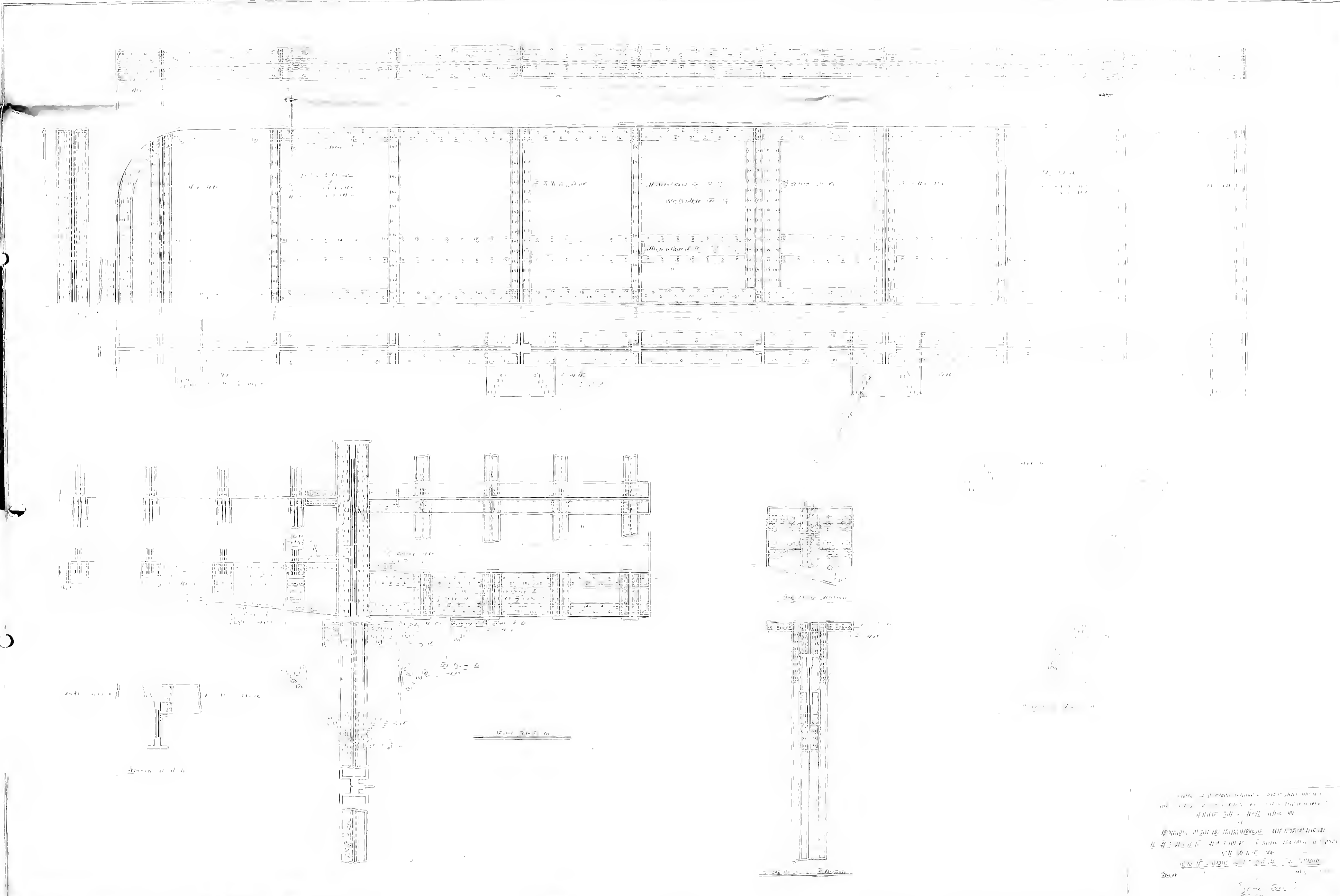
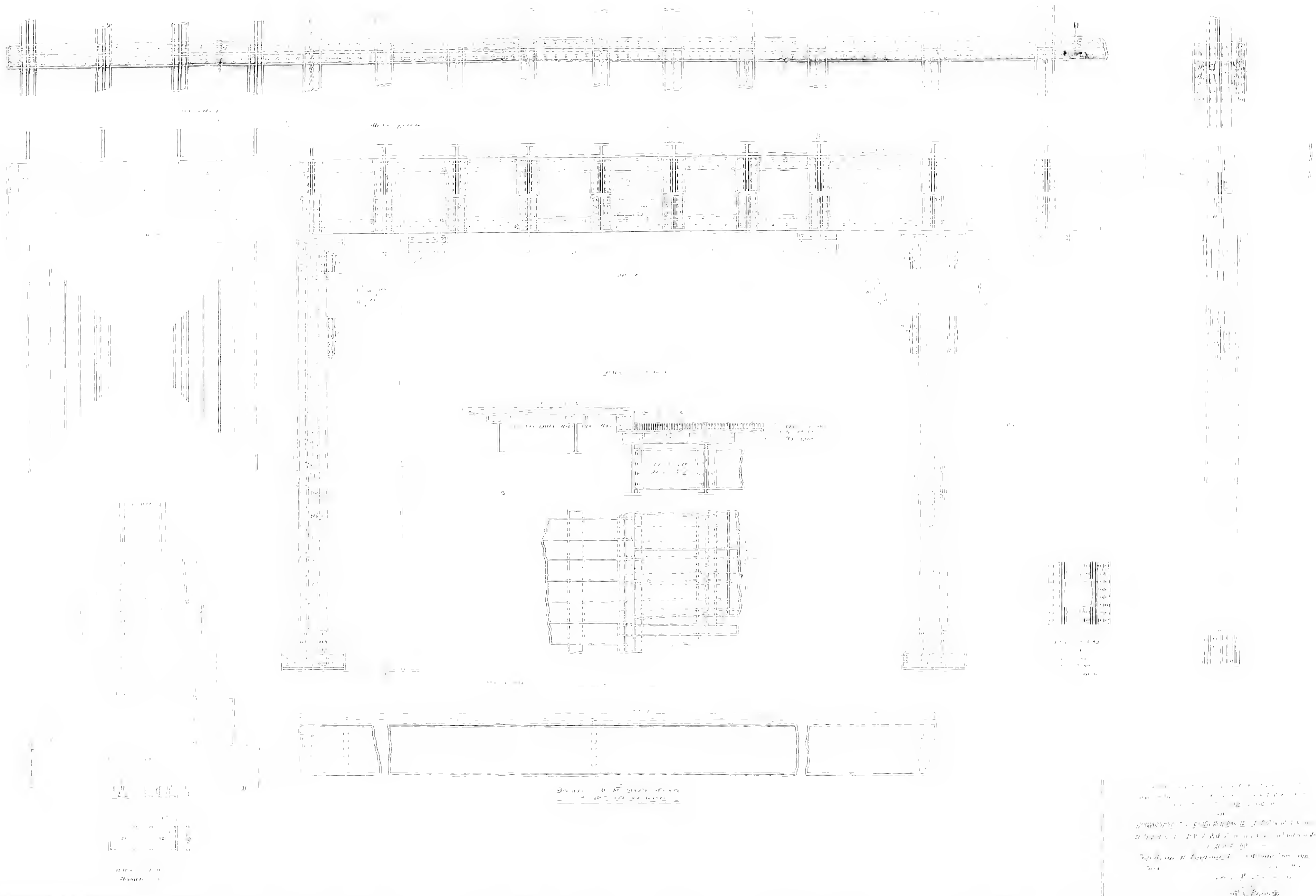


PLATE
MIDDLE GIRDER





CIVIL ENGINEERING DEPARTMENT.

ARMOUR INSTITUTE OF TECHNOLOGY.

THESIS DESIGN

of a

PROPOSED BRIDGE APPROACH,

LASALLE AVENUE, CHICAGO, ILLINOIS.

—— PLATE V. ——

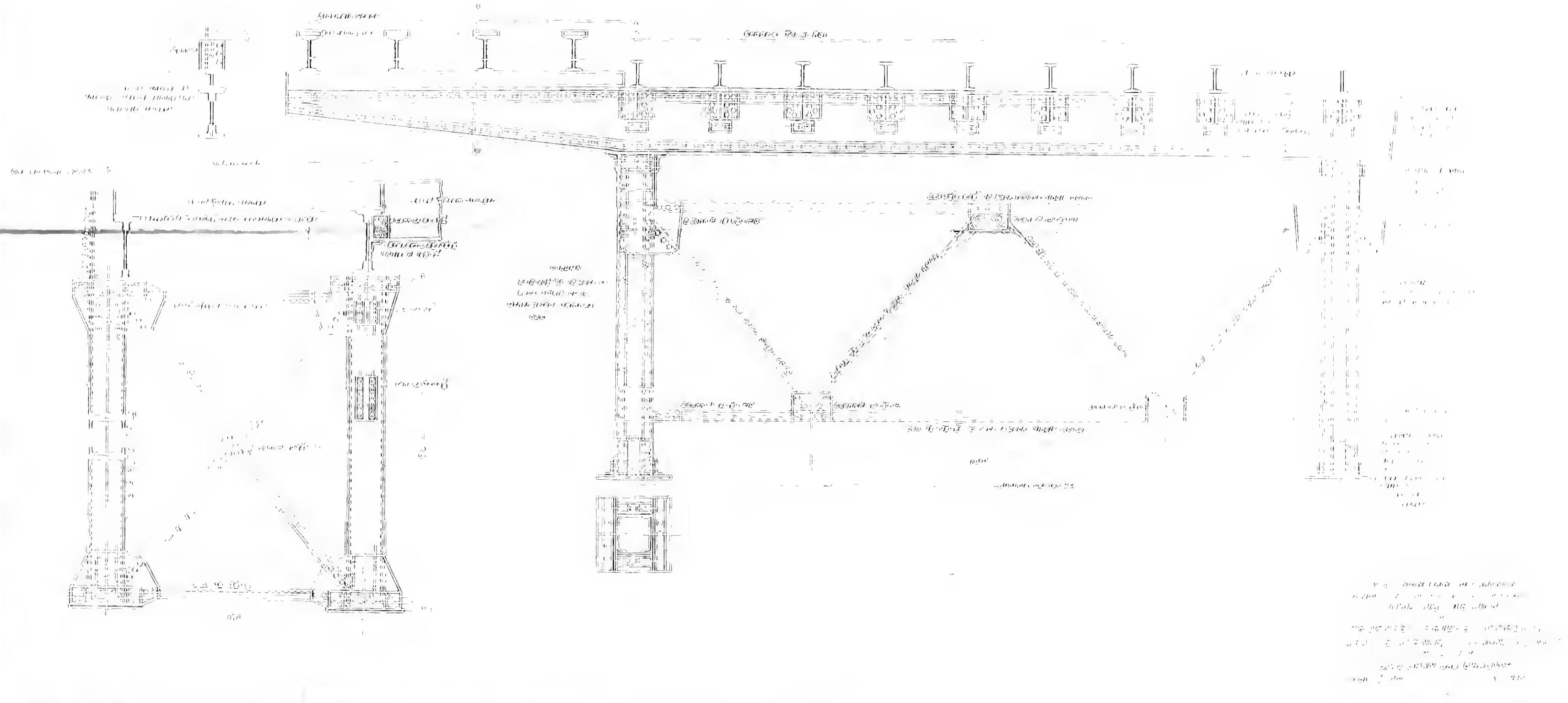
END SPAN and BRACING.

Scale - 3/4" = 1'-0". May - 1908.

[illegible]

[illegible]

Wm. C. Converse



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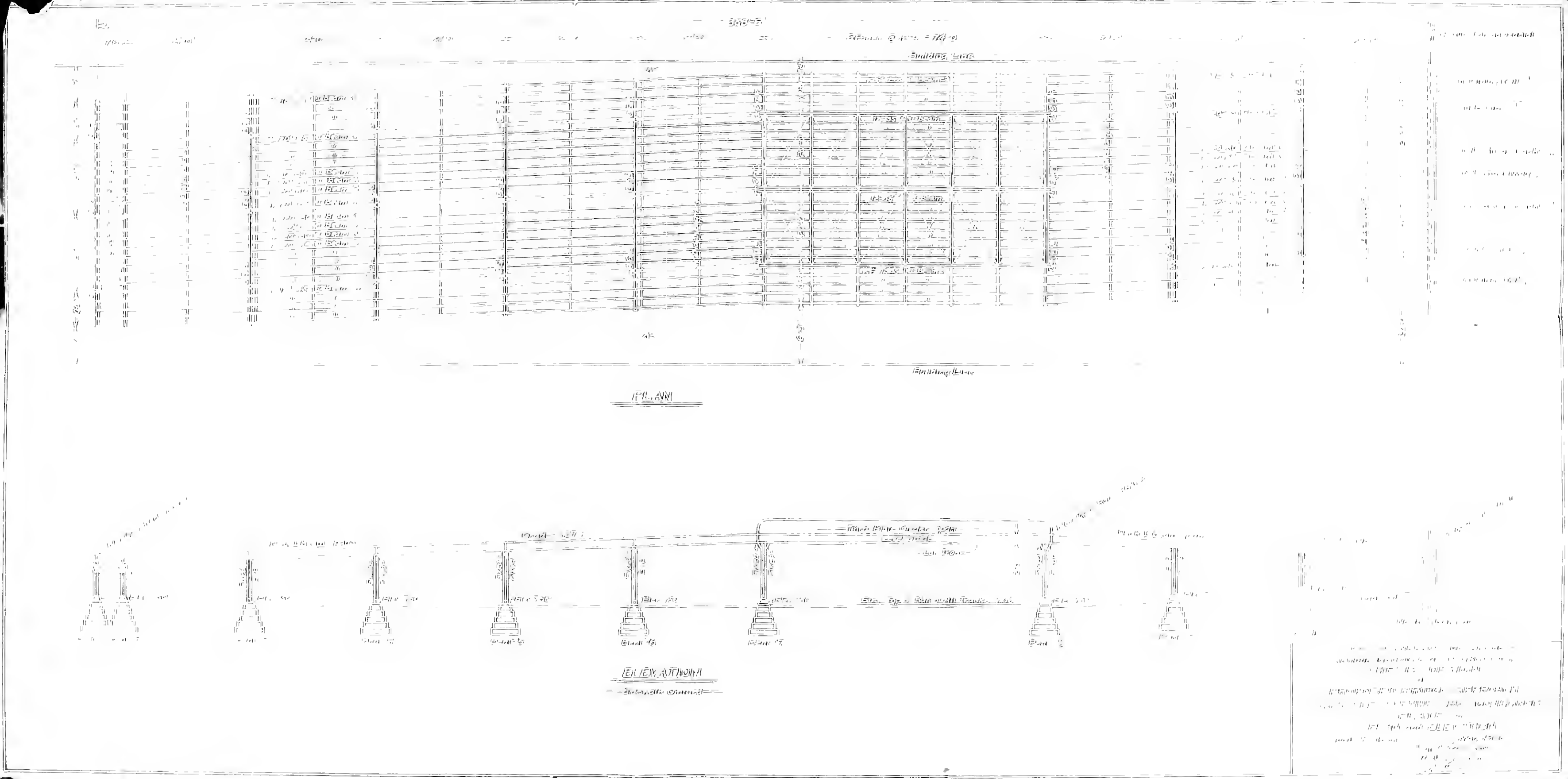
LA SALLE AVENUE CHICAGO, ILLINOIS.

PLATE #6

PLAN and ELEVATION.

Scale 1" = 12 ft. May 1908.

R. L. Larson
W. J. Converse
J. Berry



Building Line
Building Line
PLAN
ELEVATION